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TECHNOLOGY OF BATCH PREPARATION IN REPLACING RAW MATERIALS

É. K. Polokhlivets,[1] I. A. Klyuchnik,[1] and V. I. Kiyan[1]

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The dependence of the batch quality on the kind of raw materials and stability of their chemical composition and the structure of the cyclogram of a batch preparation is analyzed. It is shown that one of the main characteristics of the cyclogram is the boundary range of the commencement of moistening of the raw mixture.

It is known that the batch quality is determined by external (fluctuation of the chemical and granulometric composition of the raw materials, presence of impurities, physical wear of the equipment, etc.) and internal (fulfillment of the requirements of the specifications of the given manufacturing process) factors. The effect of the external factors on the quality of the batch has been studied in many works [1, 2], whereas data on the effect of internal factors are scarce and require additional study and refinement. At the same time, as we established in [3], the latter determine the quality of the batch to a considerable degree.

At first sight, the technology of batch preparation used today in the production of sheet glass seems to be quite simple. It consists in proportioning the raw materials in correspondence with the prescription, their moistening, mixing, feeding of the prepared batch into hoppers and transporting to the melting furnace. However, this apparent simplicity can make the producer forget about the necessary correction of the process of batch preparation when some of the components are replaced, which in some cases can lead to uncontrollable worsening of the quality of the product.

The Avtosteklo Production Association prepares batches used for manufacturing polished sheet glass using two automatic LAD688 proportioning lines installed in 1982. The lines are equipped with standard devices and have 10 automatic dosing apparatuses (the description of the design of the LAD688 line does not mention reserve unused proportioners), namely, the first two (functional and auxiliary) serve for weighing portions of quartz sand, the next pair (functional and auxiliary) are used for weighing soda, the rest are used for weighing dolomite, aluminum-bearing raw materials, chalk, and sodium sulfate. A detailed description of the line for proportioning the raw materials and preparing the batch is given in [3].

Table 1 presents the actual fluctuations of the content of oxides in the raw materials used by the plant. It can be seen that dolomite from the Elenovskoe Deposit and kaolin from the Prosyanovskoe Deposit have a higher content of iron oxide than Bosnian dolomite and Vishnevogorskoe feldspar, and the content of the other oxides fluctuates considerably.

In accordance with the requirements in [2] we present in Table 2 the data from an analysis of the mean monthly distribution of the prepared batch with respect to the quality categories for the case where the proportioning and mixing department operated with Vishnevogorskoe feldspar concentrate and Bosnian dolomite (1st period), after replacement of Bosnian dolomite by Elenovskoe dolomite (2nd period), and for a mixture of Prosyanovskoe kaolin and Elenovskoe dolo-

[1] Avtosteklo Production Association, Konstantinovka, Russia.

TABLE 1

Raw material	Deposit	Content, wt.%						
		SiO_2	Al_2O_3	Me_2O	Fe_2O_3	TiO_2	CaO	MgO
Dolomite (GOST 23672–79)	Bosnian (North Caucasus)	0.40 – 0.92	0.10 – 0.16	–	0.005 – 0.012	–	31.20 – 32.30	17.70 – 18.20
Feldspar concentrate (GOST 13451–77)	Vishnevogorskoe (the Urals)	63.80 – 64.90	20.47 – 21.14	13.35 – 13.90	0.23 – 0.32	–	0.62 – 0.83	0.07 – 0.11
Dolomite (OST 1484–82)	Elenovskoe (Donbass)	0.34 – 2.18	0.04 – 0.43	–	0.15 – 0.34	–	31.23 – 35.88	14.92 – 20.23
Kaolin (TU U21 – 3-93)	Prosyanovskoe (Ukraine)	46.59 – 48.90	35.31 – 37.59	0.33 – 2.86	0.77 – 1.03	0.32 – 0.92	0.21 – 1.09	0.05 – 0.25

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mite (3rd period). The table also contains data on the use of specific cyclograms in the process of batch preparation. The main fragments of the structure of the cyclograms (the time and order of arrival of the raw materials and the moisture into the mixture) are presented in Table 3. The widened structures of the cyclograms and the method of their plotting are considered in [3].

For convenience of analysis of the cyclograms, we will introduce notation directly connected with a specific characteristic, i.e., the boundary interval of commencement of moistening. This parameter is determined as the time interval between the end of the arrival of moisture in the mixer and the beginning of feeding of the first component of the batch that can potentially react with the water [3]. For example, we will use P.37 to denote a cyclogram with a positive boundary interval of commencement of moistening equal to +37 sec, M.29 to denote a cyclogram with a negative value of the parameter equal to – 29 sec.

The batch based on feldspar concentrate and Bosnian dolomite was prepared in accordance with cyclogram P.37 and was characterized by the total fraction of the first three mixture quality categories (the deviation from the specified composition of the components amounted to ± 0.6%) ranging between 76.57 to 81.30% (see Table 2). The yield of poorly conditioned mixture (with deviation from the specified composition exceeding 1%) amounted to 0.02 – 2.27%.

The reduction of the total fraction of the first three quality categories at the end of the 1st period was caused by incidental introduction of alumina instead of feldspar and disturbances in the operation of the proportioning system. The boundary interval of commencement of moistening (see Table 3) calculated by the formula

$$\tau_b = \tau_m - \tau_c,$$

where τ_m is the time when the moisture begins to arrive into the mixer and τ_c is the time when the component interacting with the moisture (sodium sulfate, kaolin, etc.) begins to arrive into the mixer, amounted to 37 sec (100 – 63 = 37).

The boundary intervals of commencement of moistening determined by this formula for cyclograms P.37, M.29 and M.19 are equal to +47, – 29 and – 19 sec respectively.

The homogeneity of liquid glass melted in a furnace with a capacity of 120 tons/day from the batch prepared in accordance with cyclogram P.37 ranged between 1.2 and 1.3°C and met the requirements of [2]. An analysis of the structure of cyclogram P.37 showed that some raw materials were partially moistened (see Table 3), which seems to have diminished the yield of high-quality products.

TABLE 2

Batch components	Period of operation	Total fraction of mixture of different categories, %*		Homogeneity of liquid glass, °C	Operation by cyclogram
		I – III	off-test (waste)		
		First period			
Feldspar concentrate	1993				
Bosnian dolomite	January	76.57	2.27		
	February	78.93	1.20		
	March	81.03	0.02	1.2 – 1.3	P.37
	April	72.09	6.25		
	May	70.51	8.45		
		75.81	3.63		
		Second period			
Feldspar concentrate	June	67.97	2.49		
Elenovskoe dolomite	July	74.09	2.73		
	August	79.59	1.93		
	September	64.43	5.06	1.5 – 1.6	P.37
	October	69.02	3.13		
	November	66.71	1.82		
	December	66.19	1.87		
	1994				
	January	58.75	4.14		P.47 (in late March and early April)
	February	66.85	1.46		
	March	69.76	0.40		
		68.33	2.50		
		Third period			
Kaolin	April	75.42	0.56	1.1 – 8.0	
Elenovskoe dolomite	May	77.71	1.11	1.1 – 3.4	
	June	75.27	1.81	1.4 – 3.2	M.29
	July	74.86	1.19	1.7 – 2.0	
		75.82	1.16	2.2	
	August	74.71	0.98	1.7 – 2.0	
	September	74.64	1.12	1.7 – 2.0	M.19
	October	75.74	1.17	1.9 – 3.0	
		75.03	1.13	1.98	

* The mean values are presented under the bars.

The replacement of Bosnian dolomite in the batch composition by Elenovskoe dolomite in the 2nd period decreased the total mean fraction of high-quality mixture from 75.81 to 68.33%. The fraction of poorly conditioned mixture amounted to 0.40 – 5.05% for a mean value of 2.5%. The maximum fractions of poorly conditioned mixture (5.06, 4.14 and 3.13%) were due to malfunction of the system of automatic control over the proportioning process. The boundary interval of commencement of moistening of the raw components was 47 sec.

The replacement of feldspar by kaolin at the beginning of the 3rd period (see Table 2) caused the appearance of solid lumps 3 – 8 mm in size of gray and white color in the composition of the batch; they arrived in the bath furnace, causing considerable fluctuations of the homogeneity of the liquid glass (up to 8°C) and the formation of batch stones, i.e., mullite [3]. A chemical analysis showed that the gray lumps in the mixture have the following composition: 74.64% SiO_2, 0.40% Al_2O_3, 13.00% Na_2O, 11.08% CaO, and 3.88% MgO. The white lumps were identified as sodium carbonate with a variable content of crystallization moisture.

All of this shows that the regime of the process of batch preparation after introduction of kaolin should be changed. The actual parameter of the boundary interval of commencement of moistening in the given case was +47 sec (see Table 3).

TABLE 3

Raw material	Time of arrival of the component in the mixer, sec							
	Cyclogram P.37 (weighed portion 1250 kg)		Cyclogram P.47 (weighed portion 1250 kg)		Cyclogram M.29 (weighed portion 1250 kg)		Cyclogram M.19 (weighed portion 800 kg)	
	beginning	end	beginning	end	beginning	end	beginning	end
Sand	49	129	49	129	55	135	55	110
Soda	89	139	89	139	131	181	128	153
Dolomite	Bosnian		Elenovskoe		Elenovskoe		Elenovskoe	
	82	112	82	112	131	161	92	112
	Feldspar		Kaolin		Kaolin		Kaolin	
Aluminum-bearing raw material	53	83	53	83	130	160	115	135
Chalk	70	120	70	120	132	182	109	124
Sodium sulfate	63	83	53	83	129	149	104	111
Water	60	100	60	100	60	100	60	85

This proves that the formation of lumps in the batch is directly connected with full moistening of the kaolin and sodium sulfate in the mixture and partial moistening of soda, chalk, and dolomite. In order to eliminate lumping, the cyclogram was corrected.

The change in the structure of cyclogram P.47 despite the use of the old raw components (kaolin, Elenovskoe dolomite) improved the quality of the batch (see cyclogram M.29 in Tables 2 and 3). In order to decrease the probability of moisture penetration into kaolin, soda and sodium sulfate, the process of the arrival of the batch components in the mixer was ordered; after moistening ended, the sodium sulfate, kaolin, soda, dolomite, chalk were deposited in strict order on the sand. The boundary interval of commencement of moistening attained – 29 sec. The mean total fraction of a mixture of the first three quality categories was 75.82% with a fluctuation range of 74.86 – 77.7%. The mean fraction of poorly conditioned batch decreased to 1.16%. The homogeneity of the mixture fell within 1.1 – 3.4% with a mean value of 2.2%. After the introduction of cyclogram M.29, lumping of the mixture was eliminated and batch stone was removed completely.

In connection with the planned replacement of VA-248 mixers with a 55-kW electric motor by VA-350 mixers with a 18-kW motor, the structure of the cyclogram had to be changed. The new cyclogram (see M.19 in Table 3) was created in accordance with the principles described in [3]. The boundary interval of commencement of moistening attained -19 sec. It can be seen from Table 2 that the total fraction of the first three quality categories was within 74.71 – 75.74% with a mean level of 75.03%. The amount of poorly conditioned mixture was 1.13%. The uniformity of the liquid glass bounded from a batch prepared in accordance with cyclogram M.19 was 1.7 – 2.0°C. An analysis of the operation of the automatic line for batch preparation made it possible to refine the dependence of the batch quality on the kind of raw material introduced, the state of the most important equipment of the line, and the structure of the cyclogram.

It was established that the replacement of Bosnian dolomite by Elenovskoe dolomite, which has a very unstable chemical composition, reduced the yield of high-quality mixture by 7 – 9%. With further replacement of the feldspar concentrate by kaolin, the mixture becomes lumpy and as a consequence, the homogeneity of its chemical composition and its quality are worsened.

By correcting the structure of the cyclogram and providing a negative boundary interval of termination of moistening, lumps are eliminated, mixing is improved, and the quality parameters of the mixture increases. This makes it possible to decrease the amount of rejected products by a factor of 1.76.

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